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SOURCES OF COAL MINE DRAINAGE POLLUTION RACCOON CREEK WATERSHED, PENNSYLVANIA

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
WHEELING, WEST VIRGINIA

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SOURCES OF COAL MINE DRAINAGE POLLUTION

RACCOON CREEK WATERSHED, PENNSYLVANIA

Work Document No. 28

This document has been prepared to record a specific water pollution control activity carried out to date in furtherance of the water pollution control program being developed in the Ohio River Basin. The information contained herein will serve as a ready reference to aid in the planning and development of the program in the Basin, for appropriate in-service training of participating personnel, and facilitating program activities with other cooperating groups.

Questions or comments relative to this material should be directed to:

Mine Drainage Unit
Planning and Evaluation Section
Upper Ohio Basin Office
Wheeling, West Virginia

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION

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Wheeling Field Station, Ohio Basin Region, personnel recommended a twofold effort to identify specific water pollution problems and to provide a basis for an abatement program. The recommendations were: (1) establishment of a detailed mine drainage source investigation to locate and quantify all coal mine drainage discharges; and (2) establishment of a county-wide network of stream water quality sampling stations for long-term monitoring. The gross pollution of Raccoon Creek and many of its tributaries was found due to coal mine drainage. Actions are recommended as a sequential approach for an abatement program, including making a priority listing, feasibility studies, water quality characterization, engineering plans, and construction.

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INTRODUCTION

In March 1967, the Wheeling Field Station, Ohio Basin Region, Federal Water Pollution Control Administration, was contacted by the Washington County Planning Commission relative to stream pollution in that county. To facilitate preparation of the water resource portion of their overall county plan, the Commission requested technical assistance in the design of a water pollution control program with particular reference to coal mine drainage. Following a discussion of the area problems as known at that time, Wheeling Field Station personnel recommended a two-pronged effort to identify specific water pollution problems and to provide a basis for an abatement program. The recommendations were:

1. A detailed mine drainage source investigation to locate and quantify all coal mine drainage discharges should be undertaken as the first major step in a comprehensive mine drainage abatement program.

2. A county-wide network of stream water quality sampling stations for long-term monitoring should be established.

To provide technical assistance toward accomplishment of the first recommendation, the Mine Drainage Unit of the Wheeling Field Station undertook a cooperative field study wherein Planning Commission personnel were trained in the methodology of source investigations. Raccoon Creek was selected for the initial investigations and the personnel training ground because of the severity of conditions and the economic constraint to development imposed by mine drainage in that watershed. Field work in the Washington County portion of the watershed was jointly conducted during the period April-June, 1967. Field work in the Beaver-Allegheny Counties portion of the watershed was completed by Wheeling Field Station personnel in October 1967.

Subsequent to the study reported in this document, Washington County Planning Commission personnel completed mine drainage source investigations in the county's watershed areas not previously studied. The Commission is currently enacting the second Federal Water Pollution Control Administration recommendation - the establishment of a stream water quality monitoring network.

A preliminary outline of the Raccoon Creek survey findings was prepared and distributed to interested agencies for immediate use in December 1967. This document contains the field observations and chemical data obtained in the Raccoon Creek drainage basin.

The conclusions and recommendations herein are subject to refinement as the water pollution control program progresses in the Ohio River Basin.

SUMMARY AND CONCLUSIONS

1. The Raccoon Creek watershed, draining 184 square miles of southwestern Pennsylvania, has been extensively mined for the extraction of bituminous coal for more than 100 years. These activities have left hundreds of underground voids and large surface-mined acreages capable of producing acidic and mineralized drainage.

2. At the request of the Washington County Planning Commission, the Wheeling Field Station, Federal Water Pollution Control Administration, United States Department of the Interior, recommended and subsequently conducted a study of mine drainage pollution sources in the Raccoon Creek watershed. During the course of this study, Planning Commission personnel were trained in the methodology of source investigations as a means of supplementing technical assistance available from the Wheeling Field Station and to strengthen the local program.

3. Raccoon Creek and many of its tributaries are grossly polluted by coal mine drainage. Raccoon Creek possesses degraded water quality due to mine drainage from a point just downstream of the community of Cherry Valley (Washington County) to its mouth, about 40 stream miles. Additionally, an estimated 30 to 40 miles of tributaries are likewise affected. The streams over most of this total distance are acidic, highly mineralized, devoid of normal aquatic life, and unsuitable for many legitimate water uses. With the exception of Potato Garden Run, tributaries to Raccoon Creek polluted by mine drainage are restricted to Washington County.

4. Some 200 mining and related sites and an estimated 10,000 acres of strip-mined area were investigated during this study. Samples for chemical analysis were collected from 157 drainage sources, 142 of which were discharging at the time of the survey. Discharges from the coal mine sources ranged from one to 3500 gallons per minute (gpm) and totalled 15.1 million gallons per day. The pH values of the effluents ranged from 2.4 to 7.7, and total acidity concentrations as high as 6120 milligrams per liter (mg/l) were recorded. Ninety-two percent of the mine discharges were acidic. The total acidity loading (less alkalinity) to Raccoon Creek and its tributaries equalled 81 tons per day.

5. Active mining operations, including one oil well, contributed less than one percent of the total mine discharges measured. Inactive or abandoned strip mines discharged about one-fourth of the total mine discharges and about 22 percent of the total mine acidity. Abandoned underground mines are the principal mine drainage pollution source in the Raccoon Creek watershed.

6. Twenty-eight principal mine drainage sources were found to contribute 87 percent of the acidity loading discharged to watershed streams. It is estimated that physical abatement of these principal sources would produce significant water quality improvement in Raccoon Creek; however, it is expected that at least one-half of the total number of sources would have to be abated to improve stream water quality to an acceptable level.

7. Recommendations for further study and an action program leading to abatement of the mine drainage problem are included in this document.

RECOMMENDATIONS

The Raccoon Creek watershed has the widespread problem of serious coal mine drainage pollution. Various measures are needed to reverse the water quality degradation that has occurred in Raccoon Creek and its tributaries. For the protection of existing and potential legitimate water uses, these measures are needed to reduce concentrations of acidity, hardness, sulfate, iron, and manganese, reduce excessive salinity, control sedimentation and high turbidity, and improve aesthetic conditions.

Present Commonwealth of Pennsylvania mine drainage pollution control and strip mine reclamation regulatory authority appears to be adequate to prevent additional stream quality degradation as a result of future mining activity. Stream quality degradation by operating coal mining and related activity is minor in this watershed. It is the residual problem of drainage from abandoned mines that will require virtually all the emphasis in the Raccoon Creek basin.

Raccoon Creek is an intrastate water body, consequently, the primary responsibility for water pollution control in this stream rests with Pennsylvania. Therefore, it is recommended that the Commonwealth proceed to develop a detailed plan to eliminate or significantly reduce mine drainage from abandoned coal mines in this basin. The detailed plan development could be conducted in cooperation with various Federal and local agencies such as the Federal Water Pollution Control Administration and the Washington County Planning Commission. It is realized that there are a

number of difficult, lengthy, and expensive tasks involved in any program to abate polluting discharges from inactive underground sites. A very major problem in this realm is the less-than-complete technical knowledge available of physical abatement methods. However, this fact should serve as additional impetus for the early inception of a watershed abatement program.

The following actions are suggested as a sequential approach for the development of an action program of mine drainage abatement in the Raccoon Creek watershed. The suggestions are based on the water quality and mine drainage source investigations performed by the Federal Water Pollution Control Administration in 1967 and, essentially correspond to the phase outline contained in Pennsylvania Ten Year Mine Drainage Pollution Abatement Program for Abandoned Mines.

1. Establishment of a mine drainage source abatement priority listing. Such priorities could be assigned utilizing the data outlined in this document. The priorities can be based upon the impact and relative contribution of each source to the total watershed problem. For example, a mine discharging high acidity and/or mineral loadings would be of a higher priority than a discharge of lesser loading located downstream of the discharge of greater pollutant loading. The priority of some sources may change as a result of (3).

2. Preliminary feasibility studies. Probably undertaken on a contractual basis, these preliminary studies would have the objectives of proposing abatement methods for the individual prioritized sources and estimating the cost of the methods.

3. Characterization of water quality with time. Coincident with the preliminary feasibility studies, a basinwide water quality sampling network could be established for repetitive water quality measurements. The network should include all important tributary streams receiving mine drainage and a number of locations on Raccoon Creek. The larger mine drainage sources should also be included. Flow measurement and chemical analyses could then be performed at these locations at regular intervals for a minimum of a 12-month water year.

   This phase of the total study will provide data for a pollution source priority listing based on the seasonal and annual pollution contribution of each source. Also, sufficient stream water quality data will be developed to permit reasonably accurate stream quality improvement predictions from contemplated corrective programs.

4. Detailed engineering plans. Based on (2) and (3), detailed engineering plans and final cost estimates could then be developed for the most applicable proposal from (2); that is, most applicable from the standpoint of the greatest water quality return to be obtained for a dollar spent.

5. Construction. Installation of physical measures deemed effective by adequate study could then be carried out. Monitoring of discharge changes with time at the altered sites and in the receiving streams must be an integral part of physical abatement. Routine maintenance at the controlled sources is also essential. Easements to or out-right purchase of land may be necessary for the Commonwealth of Pennsylvania to obtain control over pollutant sources on private property. Institutional changes also may need to be sought to enable the state government to achieve site control by the expenditure of public monies on private property. The acquisition of mineral rights in the areas of source abatement projects may be necessary to prevent future mining activity from destroying the physical controls.

It is further recommended that, in all phases of the described abatement program, the Commonwealth of Pennsylvania seek technical and financial assistance from all appropriate agencies of the Federal Government.

DESCRIPTION OF AREA

Raccoon Creek rises in northwestern Washington County, Pennsylvania and flows north some 46 miles to the Ohio River at a point about 30 miles below Pittsburgh, Pennsylvania. The watershed drains 184 square miles including portions of Washington, Allgeheny, and Beaver counties. Only a small percentage of the drainage area is in Allegheny County. Beaver and Washington Counties contain 94 and 72 square miles, respectively, of the watershed area. The basin is long and narrow in shape measuring about 26 miles in length and about 11.5 miles at its maximum width (east-west). The principal tributaries to Raccoon Creek are Traverse Creek, Service Creek, and Burgetts Fork.

The Raccoon Creek basin is bounded on the east by the Chartiers Creek basin, on the south and west by a number of minor Ohio River tributaries, and on the north by the Ohio River.

This area is part of the unglaciated Appalachian Plateaus physiographic province, a broad dissected upland underlain by essentially horizontal sedimentary rocks. Streams have dissected the area so that most of its plateau surface is no longer evident. The present surface consists mainly of broad, rounded ridges and intervening valleys.

The principal communities in the watershed are Washington and Burgettstown with populations of 23,545 and 2,383, respectively, in 1960.

A privately-owned recreation and nature study area of some 300 acres is located along both banks of Raccoon Creek in Beaver County. This is the Wildflower Reserve owned by the Western Pennsylvania Conservancy, a citizens' action group dedicated to perpetuating natural scenery and beauty. The polluted, sterile Raccoon Creek meanders through the beauty of this landscape in sharp contrast to the setting and purpose of the Reserve.

Proposed Impoundment

The first draft of the Sub-Region F report of the "Report for Development of Water Resources in Appalachia," prepared by the U. S. Army Corps of Engineers, lists a potential reservoir for Raccoon Creek. The potential reservoir is suggested for multi-purpose usage to promote economic development in the sub-region. The potential dam site is located on Raccoon Creek near its mouth in Beaver County and the structure would have a maximum storage capacity of 155,000 acre-feet. The present water quality of Raccoon Creek would preclude many legitimate uses of stored water in such a development.

COAL MINING

History

Although the Raccoon Creek watershed is contained in parts of three counties, significant coal mining activity has been limited to the Washington County portion of the watershed. Therefore, only Washington County data are included in this section.

The mining of coal in Washington County began in the late eighteenth century. The first coal mine known to exist in the county was recorded on a map of the city of Washington (then Bassettown) dated 1781. Other outcrop mines were soon opened in Coal Center and Canonsburg. By 1820 the county was dotted with small mines for the heating of local homes and the powering of small forges.

Early expansion of the coal mining industry in this area was prompted by exhaustion of the virgin timber supply in nearby Allegheny County. By 1840 the Pittsburgh area manufacturers needed a new fuel supply. Lock and dam construction on the Monongahela River and the construction of railroads provided dependable supply routes for Washington County coal to reach the Pittsburgh manufacturing complex. By 1880 Washington County was sending 700,000 tons of coal annually to market.

The 1880 - 1930 period marked an almost constant annual increase in coal production. By 1900 production had reached 4.8 million tons and by 1920 production was 23.3 million tons annually. A record high of 24.5 million tons was reached in 1923. In contrast, Washington County coal production in 1966 was 14.1 million tons.

In recent years, the operation of "captive" coal mines by large steel companies has created a certain amount of stability in a relatively unstable industry, historically. In the county, steel companies currently own seven of the nine major underground mines.

Drainage trickling into a nearby stream from that first mine in 1781 was likely the first small instance of local mine drainage pollution in the county. Additional hundreds of coal mines were opened before 1920. These mines generated hundreds of thousands of gallons of mine drainage water which polluted Raccoon Creek and many other Washington County streams. In large part, this drainage persists to the present even though nearly all the mines have long since been abandoned.

Coal Production

Total reported coal production in Washington County from 1881 to the present is in excess of one billion tons. The mining areas of the Raccoon Creek watershed have contributed proportionately to the county total. Total production in the county during 1966 was 14.1 million tons from 38 mines. Production was divided between surface and underground mining operations in the ratio of 0.7 million tons to 13.4 million tons respectively.

The Pittsburgh coal seam has been, and is currently, the primary source of coal in Washington County. Scattered mining, primarily for local domestic use, has occurred in other coal seams.

Coal production within the Raccoon Creek drainage basin in 1967 (the time of the mine drainage source investigation) is estimated at less than 100,000 tons.

Coal Reserves

Significant coal reserves in the Raccoon Creek watershed are limited to Washington County. Twenty named coal beds exist below the land surface. Recoverable coal reserves have been estimated, however, for only five of the beds. The named beds containing potentially mineable reserves are the Washington, Waynesburg, Redstone, Pittsburgh, and Upper Freeport. The estimated recoverable coal reserve in Washington County is 2,129 million tons.

In the Raccoon Creek drainage area of Washington County, potentially mineable coal (under current mining requirements) is almost exclusively limited to the Pittsburgh bed. No recoverable reserve estimate on watershed lines is currently available, however, large blocks of the Pittsburgh bed in the Raccoon Creek watershed have been mined out.

STREAM WATER QUALITY

Raccoon Creek and many of its tributaries are grossly polluted by coal mine drainage. Raccoon Creek possesses degraded water quality due to mine drainage from a point just downstream of the community of Cherry Valley (Washington County) to its mouth, about 40 stream miles. Additionally, an estimated 30 to 40 miles of tributaries are likewise affected. The streams over most of this total distance are acidic, high mineralized, devoid of normal aquatic life, and unsuitable for many legitimate water uses. With the exception of Potato Garden Run, mine drainage-polluted tributaries to Raccoon Creek are restricted to Washington County.

During the course of the field study phase of technical assistance to the Washington County Planning Commission, 12 stream locations were sampled for chemical analysis. Certain of these sampling stations were selected to measure the cumulative effects of mine drainage and municipal and industrial wastes at stream locations representative of principal problem areas. The discussion in this document is limited to consideration of mine drainage effects. A description of these stations is given in Table 1. The locations are shown on Figure 1. Table 2 presents pertinent water quality data from the stream stations.

Station No. 0820

Burgetts Fork near Atlasburg is unaffected by mine drainage. The stream at this location is characterized by low specific conductance and alkaline pH. Iron, manganese, sulfate, and hardness values were found to be slightly higher than usually desired but within the normal range of natural stream water quality in bituminous coal field areas.

Table 1

Stream water quality sampling stations, Raccoon Creek watershed, Pennsylvania

Station No.	Sampling Period	Stream	Location
0588	June - August, 1966	Raccoon Creek	Near Mouth
0820	April - June, 1967	Burgetts Fork	Near Atlasburg
0821	April - June, 1967	Burgetts Fork	Near Mouth
0822	April - June, 1967	Raccoon Creek	Just above Burgetts Fork
0823	April - June, 1967	Little Raccoon Run	Near Mouth
0834	May - June, 1967	Raccoon Creek	Washington-Beaver County Line
1074	May 1967	Unnamed tributary to Burgetts Fork	Near Mouth
1085	May 1967	St. Patrick Run	Near Mouth
1087	May 1967	Chamberlain Run	Near Mouth
1088	May 1967	Brush Run	Near Mouth
1090	May 1967	Dilloe Run	Near Mouth
4632	October 1967	Potato Garden Run	Near Mouth

Table 2

Stream water quality data, Raccoon Creek watershe

Station Number	No. of Samples	Flow (cfs)	pH	Specific Conductance (Micromhos/ centimeter)	Total Acidity 2/ mg/l	Total Acidity 2/ lb/day	Total Hardness mg/l	Total Hardness lb/day
0588	6	34	4.0	1500	245	49,800	627	116,800
0820	3	10.1	7.3	360	0	0	161	7,700
0821 (1084) 3/	4	34	4.7	1380	421	52,800	477	78,200
0822	3	31	4.0	1230	648	81,600	310	49,100
0823 (1086) 3/	4	28	4.3	1610	321	26,400	113	53,100
0834 (1089) 3/	3	88	3.6	1770	518	226,000	583	263,800
1074	1	5.2	3.7	2630	354	9,980	915	25,800
1085	1	4.4	3.9	1700	340	8,100	546	13,000
1087	1	0.6	4.7	1400	263	795	654	2,000
1088	1	10.9	6.6	3000	0	0	2320	136,300
1090	1	2.0	4.7	2000	372	3,960	920	9,790
4632	1	2.3	3.4	2850	865	10,700	765	9,400

1/ Values are averages of the number of samples taken. Average values have be

2/ Where present, alkalinity values were subtracted from total acidity values.

3/ Station Nos. 0821, 0823, and 0834 pertain to sampling conducted prior to the
The station numbers in parentheses pertain to additional sampling during the
Data from each additional sample is included in Appendix A at the end of thi

Table 2

water quality data, Raccoon Creek watershed, Pennsylvania 1/

Total Acidity 2/		Total Hardness		Sulfate		Total Iron		Manganese		Aluminum	
mg/l	lb/day	mg/l	lb/day	mg/l	lb/day	mg/l	lb/day	mg/l	lb/day	mg/l	lb/day
245	49,800	627	116,800	463	78,900	3.4	625	8.3	1690	27.4	5060
0	0	161	7,700	87	2,150	0.9	64	0.4	65		
421	52,800	477	78,200	1031	152,800	42	7,110	8.3	1250		
648	81,600	310	49,100	1023	123,100	51	8,120	6.4	771		
321	26,400	113	53,100	1091	94,000	7	756	17.1	1426		
518	226,000	583	263,800	1337	605,300	21	10,890	11.6	5270		
354	9,980	915	25,800	1800	50,800	12	338	16.8	474		
340	8,100	546	13,000	1020	24,300	5	114	12.4	295		
263	795	654	2,000	1060	3,200	1	3.6	10.0	30		
0	0	2320	136,300	2345	137,800	0.3	18	11.2	658		
372	3,960	920	9,790	1600	17,000	4	37	24.5	261		
865	10,700	765	9,400	1680	20,700	31	379	19.6	241		

of samples taken. Average values have been rounded.

were subtracted from total acidity values.

pertain to sampling conducted prior to the mine drainage source investigations.
s pertain to additional sampling during the source investigations.
is included in Appendix A at the end of this document.

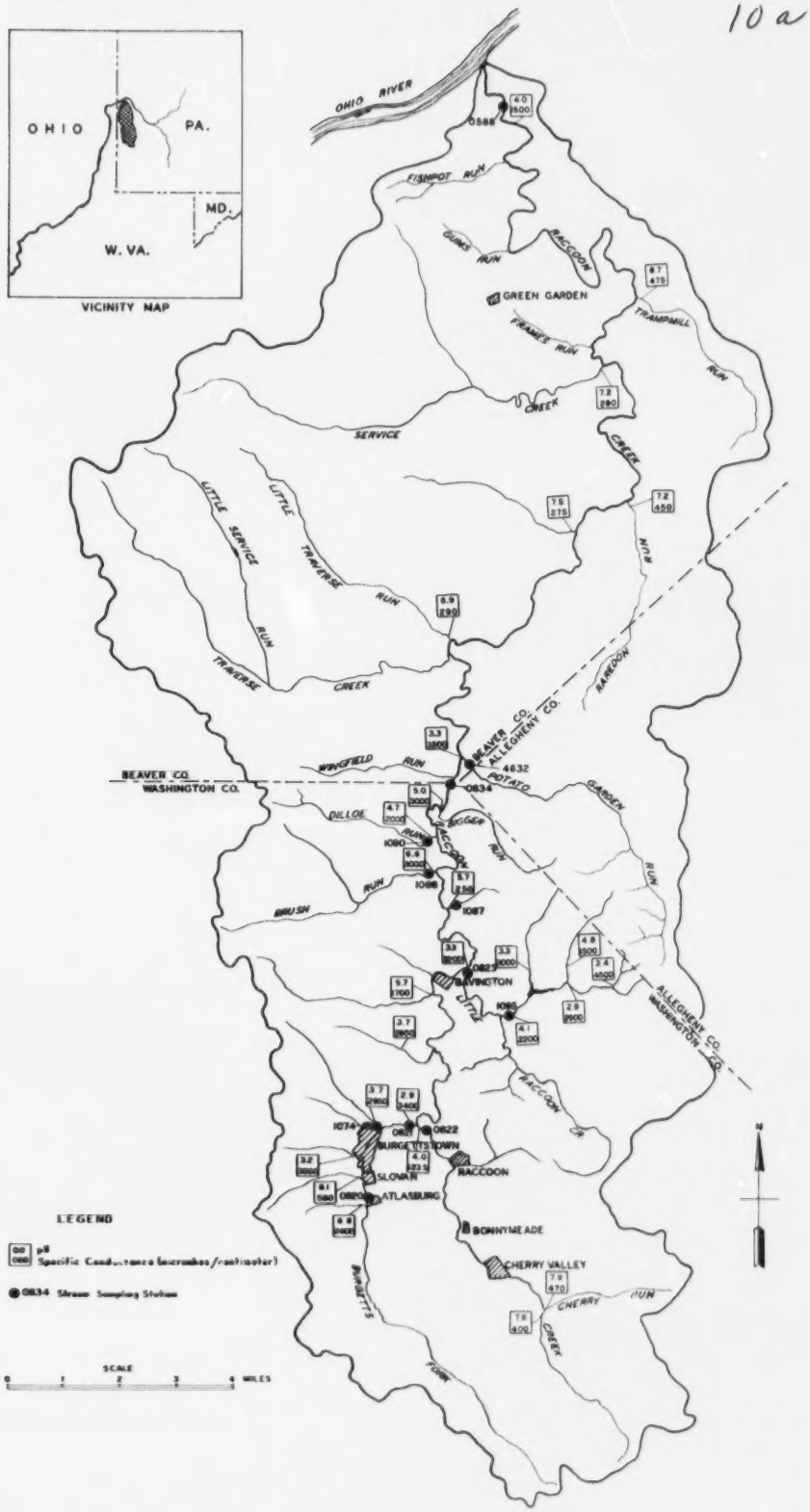

FIGURE 1. STREAM WATER QUALITY, RACCOON CREEK AND TRIBUTARIES

Station No. 0821

Burgetts Fork near its mouth, some five stream miles downstream from Station No. 0820, is acidic and highly mineralized. Burgetts Fork discharged an average of 26 tons of equivalent sulfuric acid to Raccoon Creek per day during the study period. Hardness, sulfate, iron, and manganese concentrations (Table 2) were very high. Burgetts Fork is the second largest contributor (tributary) of acidity, hardness, sulfate, and iron loadings to the main stream.

The drastic water quality change exhibited in Burgetts Fork from Atlasburg to the mouth is due to a number of surface and underground mine discharges to Burgetts Fork and its tributaries from the west. Six discharges identified as principal sources are located in this area.

Station No. 1074

This unnamed tributary to Burgetts Fork (Figure 1) enters from the northwest and drains a large strip-mined acreage. This stream is acidic, highly mineralized, and contributed some five tons of acidity per day to Burgetts Fork during the study period. The concentrations of mine-drainage related constituents were all very high (Table 2).

Station No. 0822

Raccoon Creek above Burgetts Fork is severely degraded by mine drainage and is more acid than Burgetts Fork with an average net acidity concentration of 648 mg/l, shown in Table 2. The acidity loading at this point totalled about 41 tons per day. The average total iron concentration was greater at this station than at any other, 51 mg/l.

Station No. 0823

Little Raccoon Run near mouth is also severely degraded by coal mine drainage. Some 13 tons per day of acidity were discharged to Raccoon Creek by Little Raccoon Run during the study period. All mine drainage-related parameters were found to be present in excessive concentrations.

Station No. 1085

St. Patrick Run, tributary to Little Raccoon Run, is a very acid stream. The pH value found at this station was 3.9. Four of the thirteen tons of acidity per day measured in Little Raccoon Run, were contributed by St. Patrick Run. All other parameters determined were in the same general range of excessive concentration as the previous stream sampling locations.

There is an abandoned water supply reservoir impounded on St. Patrick Run. This body was owned by the West Penn Water Company and served as the water supply for McDonald, Pennsylvania. The rapid expansion of strip mining upstream of the reservoir during World War II caused acid drainage to enter the reservoir. This municipal supply was abandoned in 1946 after a lengthy court battle.

Station No. 1087

Chamberlain Run enters Raccoon Creek just downstream of the community of Bavington. Similar to the other tributaries sampled, it is quite acidic and of severely degraded water quality. At the time of sampling, the measured flow was less than one cubic foot per second (cfs) and therefore the stream's acid load contribution to the main stream was small.

Station No. 1088

Brush Run near mouth is very highly mineralized as a result of drainage from strip-mined land but alkaline in character rather than acidic. About 1.5 tons per day of alkalinity were discharged to Raccoon Creek and served to reduce the main stream acidity by approximately the same amount on a weight basis.

Brush Run was the largest tributary contributor, however, of hardness, and the second largest tributary contributor of sulfate to Raccoon Creek. The hardness and sulfate loadings were 68 and 69 tons per day, respectively.

Station No. 1090

Dilloe Run near mouth is seriously degraded, acidic, and highly mineralized. All parameters measured were found to be present in excessive concentrations. Dilloe Run discharged two tons per day of acidity to the main stream.

Station No. 0834

Raccoon Creek at the Washington-Beaver County Line carried the greatest acid loading of any point of measurement in the watershed, 113 tons per day. This station also exhibited the greatest loadings of hardness, sulfate, iron, and manganese. The largest loading of these constituents carried by Raccoon Creek is immediately below the last contribution of mine drainage pollutants, Potato Garden Run, just downstream of Station No. 0834. Although a water quality sampling station was not located in this reach of the main stream, the sum of like values from Stations No's. 0834 and 4632 will equal the loadings carried by Raccoon Creek at that point.

These loadings are:

Total Acidity	-	118 tons per day
Hardness	-	137 tons per day
Sulfate	-	313 tons per day
Total Iron	-	5.6 tons per day
Manganese	-	2.8 tons per day

Station No. 0588

Raccoon Creek near mouth is of the same mineralized and acidic quality as the upstream locations previously discussed. However, the loadings of the parameters studied are reduced from those found at Station No. 0834. The values at these two locations are not directly comparable because of dissimilar samping times and streamflow. Reductions in loadings and concentrations are expected, however, to result from dilution and neutralization effects from the entry of alkaline tributaries into Raccoon Creek in the reach from Potato Garden Run to the Ohio River.

During the sampling period, Raccoon Creek discharged an average of 25 tons per day of acidity to the Ohio River. The pH averaged 4.0 and hardness and sulfate concentrations were extremely high. Concentrations of sulfate, iron, and manganese were somewhat reduced over upstream levels, however, as a function of the precipitation of chemical sediments (primarily iron sulfates) in the lower half of Raccoon Creek.

Station No. 4632

Potato Garden Run is the last acid tributary in the downstream direction to enter Raccoon Creek. Near its mouth, this stream contained 865 mg/l total acidity and discharged over five tons per day of acidity to the main stream at the time of measurement. Potato Garden Run drains portions of Allegheny and Beaver Counties and is the only mine drainage-polluted tributary to Raccoon Creek not contained in Washington County.

Biology

A biological evaluation of Raccoon Creek at Station No. 0588 was made during the study to determine the effect of pollution conditions upon normal aquatic fauna. The few benthic organisms collected consisted of acid-tolerant forms. The substrate of the stream was stained red and the rocks were crusty and cemented together. No fish life was observed at this location. The habitat is considered severely degraded and intolerable to a typical aquatic fauna.

In summary, all mine drainage-affected stream locations sampled are characterized by acidic pH values generally below 4.7 and specific conductance values exceeding 1200 micromhos per centimeter. Alkalinity fractions were consistently depleted to zero and total acidity values generally exceeded 250 mg/l and approached 2000 mg/l in one instance. Most of the streams are extremely hard (300 mg/l total hardness) and contain sulfate ion in excess of 1000 mg/l. All streams studied contained total iron in excess of 1.0 mg/l and most streams contained more than five mg/l. Manganese concentrations were consistently high as well, often higher than iron concentrations in the same water. Aluminum concentration values at Station No. 0588 (Raccoon Creek near mouth) were very high.

In the realm of visual observations, most of the watershed streams draining mined areas are characterized by red appearance and/or the presence of orange-yellow precipitate in suspension or on the stream bottom. Fine coal particles are often mixed with the bottom sediments and the additional burden of sand and silt materials is mixed with the precipitate and coal particles, especially downstream of strip-mined areas.

During periods of high stream runoff, the streams are extremely turbid due to flushout and resuspension of stream bottom deposits that resulted from drainage of mined areas.

SOURCES OF MINE DRAINAGE

Some 200 mining and related sites and an estimated 10,000 acres of strip-mined area were investigated during this study. Samples for chemical analysis were collected from 157 drainage sources, 142 of which were discharging at the time of the survey. The non-discharging sources were nearly all strip mine ponds. Discharges from the coal mine sources ranged from one to 3500 gallons per minute (gpm) and totalled 15.1 million gallons per day. The pH values of the effluents ranged from 2.4 to 7.7 and total acidity concentrations as high as 6120 milligrams per liter (mg/l) were recorded. Ninety-two percent of the mine discharges were acidic. The total acidity loading (less alkalinity) to Raccoon Creek and its tributaries equalled 82 tons per day.

A detailed description of the mine drainage sources in the Raccoon Creek basin follows.

Headwaters

Raccoon Creek water quality is unaffected by mining activity upstream of the community of Cherry Valley (Figure 1). Minor tributaries and the main stream in this headwaters area exhibited pH values of 7.5 or above and specific conductance values averaged above 500 micromhos per centimeter.

The first visual evidence of coal mining activity is encountered near Cherry Valley along two unnamed tributaries to Raccoon Creek. Piles of long-abandoned mine refuse remain at these locations from previous nearby mines (Figure 2). The water quality of the main stream and tributaries remains virtually unaffected by mine drainage to a point just below Cherry Valley, near Bonnymeade. The water quality of Raccoon Creek is seriously degraded from this point to its mouth, some 40 miles downstream.

The first discharge to enter Raccoon Creek is No. 778 (Figure 2), an abandoned oil well effluent of 46 gpm. During the course of the source investigation, oil well discharges were documented when encountered. No. 778 is acidic and contributed a small acidity loading of 63 pounds per day to Raccoon Creek. The discharge is predominantly a sulfate-water rather than a chloride-water which suggests a shallow subsurface origin of the effluent.

Just downstream of No. 778, near Bonnymeade, Mine No. 1071 discharges a large acidity loading of 12 tons per day to Raccoon Creek. This is the largest mine discharge encountered with respect to flow, 3500 gpm, in the Raccoon Creek watershed. Raccoon Creek is continually acidic from this point to its mouth.

About one-half mile downstream of Mine No. 1071, Raccoon Creek receives drainage by way of a small unnamed tributary from the mine source discharging the largest single acid load in the watershed. Mine No. 1070, an abandoned drift mine, discharged the equivalent of 25 tons per day of acidity. The 684 gpm discharge had a total acidity concentration of 6120 mg/l and exhibited a pH level of 3.0. The effluent also carried the largest loading of sulfate - 30 tons per day; iron - 4 tons per day; and manganese - 410 pounds per day, of all sources in the basin. Recent contour strip-mining has occurred in the coal seam outcrop in the vicinity of Mine No. 1071.

Mine Nos. 1070 and 1071 are believed to be openings to the abandoned Verner Mine of the Carnegie Coal Company. Both of these discharges are identified as principal mine drainage sources in a later section.

From the vicinity of Bonnymeade north to the community of Raccoon, strip mining is evident along both sides of the main stream.

At the community of Raccoon, an unnamed tributary enters the main stream and adds a large slug to the already acidic stream. Eighteen discharges, from drift and strip mines, totalled an acid load of over eight tons per day received by the tributary. Ninety-two percent of the loading was from drift mines undisturbed by later strip mining. Four of these sources are identified as principal mine drainage sources. (See page 29.)

From the community of Raccoon to the confluence with Burgetts Fork, four more significant mine drainage sources were encountered. These sources discharged a total acidity loading of 542 pounds per day (lb/day) from two drift mines and two strip mines.

The total acidity discharge received by Raccoon Creek above Burgetts Fork from 26 sources is about 46 tons per day. The average unneutralized acid load carried by Raccoon Creek just above Burgetts Fork during the study was about 42 tons per day. Although the comparison is not direct, these data indicate that some four tons per day of mine drainage acidity is neutralized by natural stream and/or soil alkalinity in the subject drainage area.

Six of the principal mine drainage sources in the Raccoon Creek watershed are located in the drainage area of Raccoon Creek above Burgetts Fork.

Burgetts Fork

Burgetts Fork is the second largest contributor (tributary) of mine acidity and related parameter loadings to Raccoon Creek. The tributary is unaffected by mine drainage from its beginning to the first significant mine drainage received by the stream near the community of Slovan. Upstream of Slovan, near Atlasburg, a large mine waste dump is located along Burgetts Fork but no measurable drainage was emanating from the dump at the time of inspection.

The first significant pollution source, Mine No. 800, is located adjacent to an unnamed tributary opposite the community of Slovan. This discharge is identified as a principal source of mine drainage pollution in the watershed. The discharge is from a borehole drainway of the abandoned Langeloth Mine, Langeloth Coal Company. The effluent carried nearly three tons per day of acidity at the rate of 270 gpm. Burgetts Fork is discolored, mineralized, and acidic from the entry of this mine discharge to its confluence with Raccoon Creek.

Immediately downstream of Slovan, about one-half mile from Mine No. 800, is a huge mine waste dump from the Langeloth Mine. The manway to the old mine is located directly behind the waste dump and has no discharge.

Mine No. 1069 is located between the Langeloth waste dump and Burgettstown. The discharge is in the area of the old Francis Mine and it is believed that this discharge is the result of later strip-mining having cut into these old workings. There are other drift mine openings without discharges nearby. Mine No. 1069 discharged 230 gpm with an acid load of 1076 lb/day directly into Raccoon Creek. There is a mine waste dump near the drainage, presumably from the Francis Mine.

In the vicinity of Burgettstown, several mine effluents discharge to unnamed tributaries in the lower two-mile reach of Burgetts Fork.

Located on the hill southwest of Burgettstown, Mine Nos. 1072 and 1073 discharge a combined total of 219 gpm carrying 1.1 tons per day of acidity to an unnamed tributary. Mine No. 1072 discharged all of the acidity loading. Mine No. 1073 is an adjacent strip mine with a small alkaline discharge. Around the same hill, in the unnamed stream valley immediately to the north, is the main opening to the abandoned Francis Mine. The effluent from this location, Mine No. 780, amounts to 36 gpm from extensive waste piles and an acid-water pond on the property. Mine No. 1072 is believed to be the main drainway from the Francis Mine and is a principal source of mine drainage in the Raccoon Creek watershed.

To the north of the Francis Mine is an extensive strip-mined area drained by the unnamed tributary to Raccoon Creek characterized by stream Station No. 1074 (Figure 1). The strip-mine drainage has been quantified by eight discharge measurements of mine effluents and streams made up of accumulated seepage water from strip mine spoil banks and ponds. These discharges totalled 1068 gpm carrying 2.7 tons per day acidity. The quantities of flow and acidity emanating from this area are quite variable because of the large strip-mined acreage contained in it.

Five tons per day of acidity was measured (one measurement) at Station No. 1074 (Table 2).

Mine Nos. 781 and 782, located on the hillside opposite Burgettstown, are effluents from drift mine openings. Their combined acid contribution to Raccoon Creek is 2.5 tons per day. Both effluents are identified as principal sources and flow at the rate of 60 gpm each.

In summary, some 20 mine drainage sources in the Burgetts Fork watershed have been located and measured. These sources total a flow of 1790 gpm and an acidity loading of nearly eight tons per day. Six of the principal mine drainage sources in the Raccoon Creek watershed are located in the drainage area of Burgetts Fork.

Raccoon Creek

Between Burgetts Fork and Little Raccoon Run on the east bank of Raccoon Creek, 11 effluent points were located. The first effluent, Mine No. 715, is one of the watershed principal sources. The discharge emanates from a drift mine opening that has completely slumped over. This source contributed 0.6 ton per day of acidity at a flow rate of 90 gpm. Along the same coal outcrop in the next two miles downstream, ten additional discharge points are located, seven drift mine openings and two strip mine effluents. The ten discharges totalled a flow rate of 316 gpm and an acidity loading of 2.3 tons per day.

Along the same reach of the main stream, on the west bank, drainage is received from a strip mining area that is a continuation of the strip mining area discussed in Burgetts Fork. This large area extends through the northern limit of the area described in this section. In this area, six strip mine drainage points were measured, three of which are categorized as principal sources. Mine Nos. 787 and 788 were flowing at the rates of 120 gpm and 195 gpm, respectively, of highly acid drainage. Mine No. 787 discharged 1.1 tons per day of acidity and Mine No. 788 carried 0.7 ton per day. A small strip area northeast of Nos. 787 and 788 discharged 75 gpm carrying another 0.7 ton per day acidity to Raccoon Creek (Mine No. 789). Three additional strip mine sources measured in this area totalled only 34 lb/day acidity from a combined flow of 25 gpm.

In this area, on either bank of the main stream, 17 discharge points were measured which totalled a discharge rate of 731 gpm and a pollution load of 4.7 tons per day acidity. The majority of the load was from strip mining sources. Four principal watershed sources are located in this drainage area.

Little Raccoon Run

Little Raccoon Run enters Raccoon Creek just north of the community of Bavington. Little Raccoon Run is one of the larger tributaries in the watershed and is an acid stream. The numerous unnamed tributaries to this stream drain sub-watersheds that have

experienced some of the heaviest and most extensive strip mining in the Raccoon Creek watershed. Conductivity values as high as 4500 micromhos and pH values as low as 2.9 were recorded in these small tributaries.

Some 37 mine drainage sources were sampled in the Little Raccoon Run drainage area, nearly all of which were discharging at the time of inspection.

In the drainage area of St. Patrick Run, principal tributary to Little Raccoon Run, 12 discharges were measured totalling a flow of 488 gpm and an acidity content of nearly three tons per day. Ten of the discharges were from inactive strip mines and two were from abandoned drift mines. The strip and drift mine sources totalled discharge rates of 298 gpm and 190 gpm, respectively, and acid loadings of 2.2 tons per day of 0.7 ton per day, respectively. One strip mine discharge and one drift mine discharge are principal watershed sources of mine drainage pollution.

One of the principal sources, Mine No. 704, is the combined flow of two drainage streams coming from strip mine pits located at the head of an unnamed tributary to St. Patrick Run. The flow of the discharge was 182 gpm and it carried an acid loading of 1.4 tons per day. It was impossible to determine by visual inspection whether the drainage had been caused by intersection of the strip mine with underground workings, however, the volume of the discharge suggests an underground source.

The other principal source, Mine No. 708, does result from the intersection of a strip cut with an old underground mine void. The intersection and drainage issuing from it are plainly visible. This discharge was measured at the rate of 180 gpm and carried an acidity loading of about 0.7 ton per day. The discharge enters an unnamed tributary.

In the drainage area of Little Raccoon Run, less the drainage area of St. Patrick Run, 23 mine discharges were located and measured. Four of the discharges were from drift mines and 19 were from strip mines. The combined watershed discharge totals were 445 gpm and 3.2 tons per day acidity. The strip mine sources composed over 80 percent of the total acid loading. One of the 23 sources is identified as a principal watershed mine drainage source.

Mine No. 732, the principal source, is an accumulation of seepage from a large strip-mined area located near the divide between Little Raccoon Run and Raccoon Creek. This drainage amounted to 60 gpm at the time of the survey and carried an acid load of 0.7 ton per day.

Considering the Little Raccoon Run basin as a whole, 35 discharging sources were located whose combined acid loading was six tons per day from nearly 1000 gpm flow. Most of the acid loading is from strip mines located generally throughout the drainage area. St. Patrick Run, the principal tributary to Little Raccoon Run, receives almost 50 percent of the total watershed acid load received. Three principal mine drainage sources are located in the total drainage area of Little Raccoon Run.

Near its mouth, St. Patrick Run carried four tons per day of acidity at the time of measurement. Little Raccoon Run carried over 13 tons per day of acidity.

Brush Run, Dilloe Run

On the west bank of Raccoon Creek, Brush and Dilloe Runs are the last tributaries to the main stream that drain coal mining areas. These streams drain the remaining portion of the large strip mining section west of Raccoon Creek whose southern limit is near the community of Burgettstown. This area has been extensively strip-mined and is characterized by highly mineralized streams.

Although six acid strip mine discharge points were measured in the Brush Run watershed totalling nearly two tons per day of acidity, Brush Run remained alkaline in its lower reach. The largest of the six discharges, Mine No. 1079, is a principal watershed mine drainage source. This discharge was 150 gpm with an acidity loading of 1.3 tons per day. The point of measurement of No. 1079 represents the accumulation of seepage from a large reclaimed and partially reclaimed strip-mined area. The acid loading from this drainage source is nearly three-fourths of the acid loading total of the six sources measured.

The hardness and sulfate loadings of the six measured sources do not begin to account for the extremely high loadings measured at Station No. 1088, Brush Run near mouth. The two loading totals from the sources measured are less than one-tenth of those at Station No. 1088. The bulk of the quantities of hardness and sulfate in Brush Run must therefore be the result of seepage over the entire watershed area disturbed by strip mining, rather than measurable point discharges.

One point of discharge in the Dilloe Run drainage area was quantified during the study, Mine No. 1078. This discharge amounted to 120 gpm and an acid loading of 1.5 tons per day from a large reclaimed strip-mined acreage. The flow is composed of the merging

of numerous small seepage streams. A loading of two tons per day of acidity was measured entering Raccoon Creek from Dilloe Run.

A combined total of 3.3 tons per day of acidity and a total flow of 401 gpm from seven discharge points was measured in the Brush and Dilloe Run watersheds.

Potato Garden Run

About 0.5 mile downstream of the Washington County line, Potato Garden Run enters Raccoon Creek in Beaver County. The headwaters of this tributary have experienced extensive surface and underground mining activity. A total of 31 mine drainage discharges were located in the drainage area of Potato Garden Run. Fourteen abandoned drift mine discharges, 16 abandoned strip mine discharges, and one active coal washery discharge were inventoried. Most of the drift mine openings were affected by later strip mining.

A total of 373 gpm was measured from the 31 sources. Sixty percent of the flow, 222 gpm, was discharged from the drift mine sources. The active coal washery had a discharge of 30 gpm. The total acid loading from all sources was about five tons per day. Over sixty percent of the loading was from the drift mine sources.

Three principal mine drainage sources in the Raccoon Creek watershed are located in the Potato Garden Run drainage area, Mine Nos. 4615, 4621, and 4628. The discharges from these three carried a combined acidity loading of 3.4 tons per day.

In upstream order, the first principal source is Mine No. 4621. This discharge emerges from the base of a strip mine highwall at the rate of 48 gpm. Although there is no evidence of underground mining at the discharge site, this area has been undermined. The strip mine appears to have cut into an underground mine and created this discharge point. The acidity loading of the discharge was 0.9 ton per day. The discharge enters an unnamed tributary to Potato Garden Run.

The second principal source, Mine No. 4615, is located near Raccoon Creek and its discharge flows directly to the main stream. This effluent emanates from a drift mine opening located in a strip mine highwall. There are two other drift openings nearby which are presumed interconnected to the one with the drainage. The discharge was at the rate of 85 gpm and carried an acidity loading of 1.5 tons per day, the largest acid loading of any mine discharge in the Potato Garden Run watershed.

The third principal source is Mine No. 4628. This discharge is located at the top of the drainage area of Potato Garden Run, almost at the top of the ridge dividing this watershed from the Little Raccoon Run watershed to the south. This 65 gpm effluent also emerges from a drift mine opening located in a strip mine highwall. The acid loading from this source was over one ton per day.

The total acid load measured from the sources located in the Potato Garden Run watershed was five tons per day (10,161 lb/day). The acid load measured at Station No. 4632, Potato Garden Run near mouth, was 5.3 tons per day (10,700 lb/day).

Raccoon Creek

The only section containing mine drainage sources that remains to be described is the drainage area to Raccoon Creek on the east bank between Little Raccoon Run and Potato Garden Run. Within this drainage area, the Chamberlain Run and Bigger Run watersheds have been mined in their upper portions. A total of 11 discharging sources were located in this section. Seven of the 12 discharged to Bigger Run, three discharged to Chamberlain Run, and the remaining one discharged to an unnamed tributary to Raccoon Creek. An aggregate of 770 gpm was discharged containing 5.2 tons per day of acidity. Two of the 11 sources were alkaline.

An unnamed tributary located just south of Chamberlain Run receives drainage from Mine No. 741 at its head. A flow of 12 gpm discharges from a pond located adjacent to a strip mine spoil pile. The acidity loading of the effluent was 139 lb/day. It is not known whether the strip mine cut into underground mine workings.

Three strip mine discharges are received by Chamberlain Run totalling 125 gpm and about 0.5 ton per day of acidity. These effluents are Mine Nos. 685, 686, and 688. No. 687 is a pond overflow which includes the discharges of Mine Nos. 685 and 686.

Bigger Run receives drainage from seven mine discharges located in its headwaters. These discharges totalled 633 gpm flow and an acid loading of 4.6 tons per day. Two of the discharges were alkaline so only five discharges comprised the large total acid loading. Two of the five acid discharges are principal watershed mine drainage sources.

Mine No. 680, a drift mine discharge of 90 gpm, carried an acid loading of 0.6 ton per day. The location of this old mine has been strip-mined and the drainage opening is exposed in the base of the highwall.

The other principal source, Mine No. 681, contributed most of the total flow and acidity received by Bigger Run. The measured discharge from this drift mine opening was 495 gpm and it carried an acid load of nearly four tons per day. The mine has been stripped out and the opening is completely slumped over. The measured discharge includes drift mine drainage and an undetermined amount of seepage from adjacent strip-mined area.

DISCUSSION

Raccoon Creek and many of its tributaries are grossly polluted by coal mine drainage. These streams are commonly acidic, highly mineralized, devoid of normal aquatic life, and unsuitable for many legitimate water uses. Nearly 80 miles of stream in the Raccoon Creek drainage area are so affected.

Some 157 mine drainage sources were identified and sampled for chemical analysis. One hundred forty-two of these were discharging to watershed streams at the time of inspection. The total measured discharge volume was 10,300 gpm, or nearly 15 million gallons per day emanating from coal mine sources within the watershed. About 44 percent of the total effluent volume was being discharged directly to Raccoon Creek in the Washington County reach of the stream. Another 32 percent of the total discharge volume was discharged to Burgetts Fork and several small unnamed tributaries to Raccoon Creek. Table 3 presents an area breakdown of mine drainage in terms of the total flow and total loadings (lb/day) of polluting constituents discharged to receiving streams in the Raccoon Creek watershed.

Acidity

From Table 3, a total acidity loading of 81 tons per day was being discharged by 142 sources at the time of the study. Nearly one-half of this total loading, 39 tons per day, was discharged directly to Raccoon Creek from only 13 mine discharge points. Forty-four mine discharges contributed an additional 22 tons per day of acidity to Burgetts Fork and several unnamed tributaries to Raccoon Creek.

An average acidity loading of 113 tons per day was measured in Raccoon Creek at the Washington-Beaver County Line, downstream of all significant mine drainage inflow. This loading is some 32 tons per day greater than the sum total of all the individual drainage sources measured (81 tons per day). There is insufficient data from this stream location (three samplings, Table 2) to allow a valid

Table 3
Mine drainage loadings
Raccoon Creek watershed, Pennsylvania

Receiving Stream	Stream Mile 1/	Drainage Area (Sq. mi.)	No. of Mine Discharges	Total Discharges (gpm)	Total Net Acidity (lb/day)	Total Hardness (lb/day)	Sulfate (lb/day)	Total Iron (lb/day)	Manganese (lb/day)
Raccoon Creek	-	-	13	4,502	78,135	23,974	114,121	10,177	697
Unnamed Tribs. to Raccoon Cr.	-	-	30	1,698	22,648	11,431	39,844	1,355	294
Burgetts Fork	37.6	18.1	14	1,616	21,674	16,898	60,575	3,947	406
Little Raccoon Run	32.4	15.8	25	463	7,307	7,117	16,156	382	372
St. Patrick Run 2/	-	5.1	12	488	5,681	4,495	12,591	432	145
Brush Run	29.6	6.3	6	281	3,620	5,603	9,742	24	199
Chamberlain Run	30.5	0.6	3	125	1,007	958	2,026	11	32
Dilloe Run	28.4	2.2	1	120	2,988	2,419	5,788	42	144
Bigger Run	27.4	1.8	7	633	9,258	8,795	22,975	817	296
Potato Garden Run	26.4	10.3	31	373	10,190	4,986	16,766	1,633	170
			142	10,299	162,508	86,676	300,584	18,820	2,755

1/ Distance above mouth of Raccoon Creek,

2/ Tributary to Little Raccoon Run.

comparison with the acidity total from upstream mine drainage sources. However, field observations indicate that surface and subsurface seepage of coal mine drainage to receiving streams represents a significant contribution to existing stream water quality in the Raccoon Creek watershed. Much of the upper watershed has the appearance of a large sponge with red-colored seepages visible over large land areas.

The cumulative net acidity loading measured at the mouth of the watershed was about 25 tons (Table 2, Station No. 0588). Although not directly comparable, the acidity difference between this point and the Washington-Beaver County Line indicates that a significant amount of stream acidity is neutralized. The primary source of neutralizing components (alkalinity) is a number of alkaline tributaries to Raccoon Creek in this stream reach.

The highest total acidity concentation encountered during the survey was 5630 mg/l from a small strip mine discharge in the Little Raccoon Run drainage area.

Alkalinity

Only four of the 142 mine drainage discharges inventoried contained alkalinity in excess of acidity. Less than ten discharges had any alkalinity present at all. Brush Run was the only alkaline stream sampled during this study.

Hardness

A total of 43 tons per day of hardness was discharged to the streams of the watershed by the sources measured. This loading comprised about 74 percent of the total hardness loading measured near the mouth of Raccoon Creek. About 28 percent of the mine drainage hardness was discharged directly to the main stream and an additional 33 percent was discharged to Burgetts Fork and a number of unnamed tributaries to Raccoon Creek.

The highest total hardness concentration encountered in the study was 3200 mg/l from Mine No. 0738, an abandoned strip mine.

Ions in coal mine drainage contributing to hardness in significant amounts are calcium, magnesium, iron, manganese, and aluminum.

Sulfate

Acidic and alkaline mine waters both commonly contain high concentrations of sulfate ion. The sources of sulfate in these effluents are free sulfuric acid and dissolved sulfate salts. The sulfate content of receiving streams in coal mining areas is indicative of the amount of total acidity that has been discharged to them through mine drainage. This sulfate content is the residual component of neutralized acidity as well as a component of acidity not yet subjected to neutralization.

Nearly 40 percent of the total sulfate loading in the mine effluents (Table 3) is discharged directly to Raccoon Creek from 13 discharge points. Although the data presented herein do not allow direct determination, knowledge of similar watersheds indicates that at least 90 percent of the sulfate present in Raccoon Creek results from coal mine drainage.

Twenty-nine sources discharged over one ton per day each of sulfate ion to Raccoon Creek and its tributaries. The maximum sulfate discharge measured was 30 tons per day, ten percent of the total sulfate discharged from all sources.

Total Iron

At most of the stream locations for which analytical data is shown in Table 2, total iron concentrations and loadings are excessive. An average daily loading of over five tons per day was measured in Raccoon Creek at the County Line while a reduced load of only 625 lb/day was measured near the mouth of the study area. Average concentration values as high as 51 mg/l were found in Raccoon Creek.

A total of 9.4 tons per day of iron was measured being discharged to receiving streams in the watershed (Table 3). Presumably, several tons per day of iron is precipitated and deposited on stream bottoms or is in intermittent stream transit between the drainage sources and Station No. 0588 near the mouth of Raccoon Creek. During high streamflow conditions the iron sediment is flushed from stream channels into the Ohio River.

One mine source (Mine No. 1070) discharged a daily iron loading of over four tons, the largest source of iron found.

Manganese

Similar to the occurrence of iron, manganese concentrations are

excessive at nearly all of the stream locations in Table 2. The highest stream concentration found was at Station No. 1090, Dilloe Run near mouth. The measured loading at the County Line station on Raccoon Creek was about 2.6 tons per day and was about 0.8 ton per day near the mouth of Raccoon Creek. Like iron, much of the manganese discharged to Raccoon Creek and its tributaries is precipitated and deposited on stream bottoms.

A total manganese load of 1.4 tons per day was measured from mine drainage sources during the study period.

Table 4 presents a summary of flow volumes and chemical loadings, by type of source, for the 142 discharging sources inventoried.

At the time of the field study there were only two active coal mining operations (and related facilities) with measurable discharges in the watershed. These operations, one strip mine and one coal washery, contributed less than one percent of the total mine drainage problem. The one oil well discharge encountered added an insignificant amount to the total of the two active discharges.

Inactive or abandoned strip mines (including combination strip mines) were found to be responsible for about one-fourth of the total mine drainage discharge in the basin which carried approximately 22 percent of the total coal mine acidity. These sources (78 in number) comprised 55 percent of all sources.

Inactive or abandoned underground mines (including combination underground mines) are the principal mine drainage pollution source type. This category, 61 sources, discharged the following percentages of each parameter: flow (gpm) - 73 percent; net acidity - 78 percent; hardness - 60 percent; sulfate - 70 percent; iron - 83 percent; manganese - 53 percent.

POLLUTION ABATEMENT

From the foregoing discussion it is apparent that particular mine drainage pollution abatement emphasis will have to be placed upon abandoned underground mine sources. Roughly three-fourths of the mine drainage pollution constituents measured in the mine effluents emanated from these sources. Abatement within this source category would effect greater water quality improvement in the lower reaches of Raccoon Creek than control of the other types of

Table 4

Mine drainage loadings
by source type
Raccoon Creek, Pennsylvania watershed

Source Type	No.	Total Discharge (gpm)	Total Net Acidity (lb/day)	Total Hardness (lb/day)	Sulfate (lb/day)	Total Iron (lb/day)	Manganese (lb/day)
Underground mines (inactive)	31	5,453	57,229	27,021	107,194	5,048	556
Strip mines (inactive)	69	2,364	30,118	30,436	77,150	2,675	1,108
Strip mine (active)	1	4	84	30	125	4	3
Combination underground mines* (inactive)	30	2,087	69,144	24,864	102,858	10,620	914
Combination strip mines** (inactive)	9	315	5,001	3,608	10,824	317	150
Coal washery (active)	1	30	869	475	1,663	117	25
Oil well	1	46	63	242	770	40	2
TOTALS	142	10,299	162,508	86,676	300,584	18,821	2,758

*Underground and strip mines together with principal portion of discharge from the underground mine.
**Strip and underground mines together with principal portion of discharge from the strip mine.

pollution sources. It is understood that economic or technical constraints may be determined that will shift abatement priority away from certain of the abandoned underground sources. However, primary emphasis should be placed upon this principal drainage source type until the feasibility of abatement of individual sources is determined.

In order to predict the stream effect of an expected efficiency level of drainage source control, it is necessary to center on a critical chemical parameter on which calculations may be based. Since Raccoon Creek is consistently a highly acid stream, few industrial acid sources are known in the basin, and acidity is usually considered the single most devastating property of coal mine drainage, total stream acidity is used in this discussion to predict water quality improvement through source control measures. Similar reductions in other mine drainage related parameters (total hardness, sulfate, iron, manganese, total dissolved solids) are expected to be coincident with acidity reduction.

Principal Sources

Twenty-eight mine drainage sources discharged more than 1000 lb/day of net acidity (total acidity less total alkalinity) during the study. These sources consist of 18 underground mines and 10 strip mines. (Some of the strip mine sources may intersect underground mine workings). All of the sources are abandoned or inactive sites. See Table 5.

Their combined acidity discharge was 141,556 lb/day (71 tons per day), about 87 percent of the total discharges measured.

In view of the present technical unknowns involved in the abatement of underground mine drainages, present methods cannot be expected to reach a high degree of effectiveness in all cases. An overall 50 percent reduction of polluting constituents from these sources might be a reasonable expectation. It may also be reasonably expected that at least a 90 percent reduction of pollution capability is achievable with strip mine drainage sources. Assuming the 50 and 90 percent reduction levels respectively, at the 28 principal sources, nearly 50 tons per day of acidity would be removed from receiving streams.

Such an acidity reduction at the points of discharge would effect a like reduction in Raccoon Creek at the County Line (Station No. 0834, Table 2), however, resultant net acidity concentrations in the stream would be expected to fluctuate to levels in excess of 200 mg/l. Raccoon Creek water quality, though improved, would be expected to continue to be characterized by excessive acidity levels.

Table 5

Principal acid mine drainage sources

Raccoon Creek watershed, Pennsylvania

Station No.	Type of Mine	Flow (gpm)	pH	Specific Conductance	Acidity (mg/l)	Acidity (lb/day)	Receiving Stream
680	Underground	90	4.5	5000	1060	1145	Unnamed Trib. to Bigger Run
681	Underground	495	3.0	3500	1295	7692	Bigger Run
704	Underground	182	3.0	4000	1290	2817	Unnamed Trib. to St. Patricks Run
708	Underground	180	3.3	2300	615	1328	Unnamed Trib. to St. Patricks Run
715	Underground	90	2.7	3000	1120	1209	Raccoon Creek
729	Strip	70	2.8	3500	1225	1029	Unnamed Trib. to Raccoon Creek
732	Strip	60	3.2	4700	2035	1465	Unnamed Trib. to Little Raccoon Run
734	Underground	468	3.1	2500	890	4998	Unnamed Trib. to Raccoon Creek
735	Underground	247	2.8	2500	2000	5928	Unnamed Trib. to Raccoon Creek
736	Underground	95	2.8	3700	1990	2268	Unnamed Trib. to Raccoon Creek

Principal acid mine drainage sources (continued)

Station No.	Type of Mine	Flow (gpm)	pH	Specific Conductance	Acidity (mg/l)	Acidity (lb/day)	Receiving Stream
771	Underground	150	2.8	2600	895	1611	Unnamed Trib. to Raccoon Creek
781	Underground	60	2.9	5000	2370	1706	Unnamed Trib. to Burgetts Fork
782	Underground	60	3.0	7000	4580	3297	Unnamed Trib. to Burgetts Fork
787	Strip	120	3.0	5000	1530	2203	Unnamed Trib. to Raccoon Creek
788	Strip	195	5.3	3000	590	1380	Unnamed Trib. to Raccoon Creek
789	Strip	75	3.0	4000	1460	1314	Raccoon Creek
798	Strip	520	3.3	1900	635	3962	Burgetts Fork
799	Strip	39	3.2	4000	2165	1013	Unnamed Trib. to Burgetts Fork
800	Underground	270	6.6	7000	1765	5718	Unnamed Trib. to Burgetts Fork
1069	Underground	230	7.2	2800	390	1076	Burgetts Fork
1070	Underground	684	3.0	6000	6120	50,232	Raccoon Creek
1071	Underground	3497	3.5	1900	560	23,499	Raccoon Creek

Principal acid mine drainage sources (continued)

Station No.	Type of Mine	Flow (gpm)	pH	Specific Conductance	Acidity (mg/l)	Acidity (lb/day)	Receiving Stream
1072	Underground	207	3.1	2200	900	2235	Unnamed Trib. to Burgetts Fork
1078	Strip	120	3.6	5000	2075	2988	Dilloe Run
1079	Strip	150	4.1	5000	1450	2610	Unnamed Trib. to Brush Run
4615	Underground	85	3.0	5200	2880	2937	Unnamed Trib. to Potato Garden Run
4621	Strip	48	3.1	5000	3090	1779	Unnamed Trib. to Potato Garden Run
4628	Underground	65	3.2	4200	2715	2117	Unnamed Trib. to Potato Garden Run
					Total	141,556	

As stated, there is insufficient stream water quality data to allow valid comparison with pollutant discharge data reported in this document. A recommendation relative to the development of relationships between stream water quality and stream discharge characteristics is given on page 4.

The principal source abatement approach outlined in this document (28 sources) will probably not be sufficient to produce acceptable stream water quality in Raccoon Creek. The principal source approach can effectively serve, however, as the first phase or priority in a larger program of drainage source abatement. Further study may show that at least one-half of all the mine drainage pollution sources must be effectively abated to gain acceptable water quality in Raccoon Creek.

OHIO RIVER
FISHPOT RUN
GUMS RUN
RACCOON
GREEN GARDEN
FRAMES RUN
TRAMPMILL
RUN
CREEK
SERVICE
CREEK
LITTLE SERVICE
LITTLE TRAVERSE
RUN
RUN
TRAVERSE
CREEK
RUN
RAREDON
BEAVER CO.
ALLEGHENY CO.
WINGFIELD RUN
BEAVER CO.
WASHINGTON CO.
POTATO
GARDEN
DILLOE
RUN
BIGGER
RACCOON
RUN
RUN
RUN

FIGURE 2. SOURCES OF MINE DRAINAGE POLLUTION, RACCOON CREEK WATERSHED, PA.

CODES FOR TABULAR DATA - PAGES A-1 THROUGH A-7

TYPE

A - Stream
B - Gas Well
C - Drift Mine
D - Strip Mine
E - Combination Drift Mine
F - Combination Strip Mine
G - Coal Washery
H - Deep Mine
I - Refuse Pile
J - Active Operation

RECEIVING STREAM

1 - Raccoon Creek
2 - Unnamed tributary to Raccoon Creek
3 - Bigger Run
4 - Unnamed tributary to Bigger Run
5 - St. Patricks Run
6 - Unnamed tributary to St. Patricks Run
7 - Burgetts Fork
8 - Unnamed tributary to Burgetts Fork
9 - Unnamed tributary to Little Raccon Run
10 - Chamberlain Run
11 - Unnamed tributary to Chamberlain Run
12 - Potato Garden Run
13 - Unnamed tributary to Potato Garden Run
14 - Unnamed tributary to Brush Run
15 - Dilloe Run

RACCOON CREEK, PENNSYLVANIA

A-1

MINE NO.	TYPE	REC. STREAM	PH	COND.	ACIDITY MG/L	ACIDITY LB/DAY	ALKALINITY MG/L	ALKALINITY LB/DAY	HARDNESS MG/L	HARDNESS LB/DAY	SULFATES MG/L	SULFATES LB/DAY	TOT. IRON MG/L	TOT. IRON LB/DAY	MANGANESE MG/L	MANGANESE LB/DAY	FLOW GPM
410677*	E	4	3.0	6500	4530	271	0	0	800	48	5700	342	570.	34.2	99.9	5.99	5
410678	C	4	3.4	6000	3250	117	0	0	600	21	4260	153	600.	21.6	99.9	3.60	3
410679	C	12	3.4	5500	1770	63	0	0	1052	37	3135	112	130.	4.7	94.0	3.38	3
410680	C	4	4.5	5000	1060	1144	0	0	555	599	2600	2808	110.	118.8	9.1	9.83	90
410681	E	3	3.0	3500	1295	7692	0	0	1304	7745	3240	19245	108.	641.5	46.0	273.24	495
410682	C	4	4.9	2300	277	26	2	0	1110	106	1380	132	6.	0.6	19.0	1.82	8
410683	C	4	5.7	1400	16	3	48	11	690	165	780	187	1.	0.2	2.4	0.58	20
410684	D	4	6.5	2000	38	5	30	4	775	111	750	108	0.	0.1	6.8	0.98	12
410685	D	11	3.2	4000	1590	286	0	0	1100	198	2500	450	20.	3.6	36.0	6.48	15
410686	D	11	3.3	3000	1275	306	0	0	1010	242	2250	540	28.	6.6	36.6	8.78	20
410687	D	10	3.2	2000	435	913	0	0	960	2016	1425	2992	1.	2.7	11.5	24.15	175
410688	D	11	4.5	1450	385	415	0	0	480	518	960	1036	1.	1.1	15.4	16.63	90
410689	D	2	3.4	3000	990	0	0	0	800	0	1960	0	8.	0.0	38.0	0.00	0
410690	D	6	3.6	3000	835	50	0	0	1080	64	2080	124	2.	0.1	37.5	2.25	5
410700	D	6	4.0	2400	440	132	0	0	1080	324	1560	468	2.	0.7	21.0	6.30	25
410701	D	6	2.9	3500	975	93	0	0	1070	102	2475	237	30.	2.9	28.8	2.76	8
410702	D	6	3.5	3000	830	49	0	0	1020	61	2100	126	1.	0.1	49.5	2.97	5
410703	D	6	2.4	4000	25	0	7	0	430	0	600	0	1.	0.0	11.0	0.00	0
410704	E	6	3.0	4000	1290	2817	0	0	1040	2271	2900	6333	106.	230.6	22.8	49.80	182
410705	D	6	3.4	4250	1630	586	0	0	825	297	3100	1116	4.	1.4	99.0	35.64	30
410706	D	5	3.2	3750	1310	314	0	0	750	180	2800	672	6.	1.4	71.0	17.04	20
410707	D	6	7.7	1500	1775	127	0	0	612	44	2400	172	43.	3.1	99.0	7.13	6
410708	E	6	3.3	2300	615	1328	0	0	414	894	1320	2851	88.	189.0	6.8	14.69	180
410709	E	6	2.9	1650	360	43	0	0	326	39	820	98	17.	2.0	7.6	0.91	10

*The prefix '41' in the mine number designates the Commonwealth of Pennsylvania.

RACCOON CREEK, PENNSYLVANIA

MINE NO.	TYPE	REC. STREAM	PH	COND.	ACIDITY MG/L	ACIDITY LB/DAY	ALKALINITY MG/L	ALKALINITY LB/DAY	HARDNESS MG/L	HARDNESS LB/DAY	SULFATES MG/L	SULFATES LB/DAY	TOT. IRON MG/L	TOT. IRON LB/DAY	MANGANESE MG/L	MANGANESE LB/DAY	FLOW GPM
410710	E	9	3.1	5000	1240	357	0	0	182	52	3360	967	95.	27.4	88.0	25.34	24
410711	E	9	3.2	4700	1205	216	0	0	1144	205	3000	540	8.	1.5	86.0	15.48	15
410712	E	9	4.4	3000	850	244	0	0	935	269	2200	633	70.	20.2	39.0	11.23	24
410713	F	9	3.0	5000	1440	518	0	0	1140	410	2940	1058	84.	30.2	99.9	35.96	30
410714	E	9	4.2	3500	300	86	2	0	1250	360	2025	583	1.	0.2	30.0	8.64	24
410715	C	1	2.7	3000	1120	1209	0	0	358	386	1620	1749	45.	48.6	7.7	8.32	90
410716	C	1	3.1	1400	340	4	0	0	695	8	740	8	2.	0.0	3.1	0.04	1
410717	C	1	2.6	3400	1245	298	0	0	530	127	2115	507	52.	12.4	14.0	3.36	20
410718	E	1	2.6	3000	1110	399	0	0	620	223	1890	680	20.	7.0	19.0	6.84	30
410719	C	1	2.8	5000	2200	792	0	0	830	298	3540	1274	188.	67.7	88.0	31.68	30
410720	E	2	2.9	2200	645	224	0	0	536	186	1440	501	9.	3.1	19.0	6.61	29
410721	D	2	3.1	4000	1535	221	0	0	992	142	2450	352	68.	9.8	55.0	7.92	12
410722	C	1	3.2	3000	935	213	0	0	875	199	2250	513	45.	10.3	29.5	6.73	19
410723	D	9	3.5	1600	565	67	0	0	612	73	1000	120	2.	0.3	13.3	1.60	10
410724	D	9	0.0	2600	5650	203	0	0	815	29	1680	60	5.	0.2	36.0	1.30	3
410728	D	2	2.8	2400	1080	155	0	0	430	61	1925	277	29.	4.2	18.0	2.59	12
410729	F	2	2.8	3500	1225	1029	0	0	550	462	2500	2100	45.	37.8	31.5	26.46	70
410730	D	9	7.7	2200	15	0	163	0	1250	0	1320	0	1.	0.0	7.4	0.00	0
410731	D	9	7.5	2000	87	0	195	0	925	0	1125	0	1.	0.0	2.8	0.00	0
410732	D	9	3.2	4700	2035	1465	0	0	1015	730	3600	2592	98.	70.6	99.9	71.93	60
410733	E	9	2.9	4500	1250	225	0	0	1345	242	3120	561	240.	43.2	74.0	13.32	15
410734	C	2	3.1	2500	890	4999	0	0	320	1797	1440	8087	43.	239.2	13.2	74.13	468
410735	C	2	2.8	2500	2000	5928	0	0	490	1452	2720	8062	165.	493.2	10.4	30.83	247
410736	C	2	2.8	3700	1990	2248	0	0	524	597	2850	3249	138.	157.3	12.0	13.68	95

RACCOON CREEK, PENNSYLVANIA

MINE NO.	TYPE	REC. STREAM	PH	COND.	ACIDITY MG/L	ACIDITY LB/DAY	ALKALINITY MG/L	ALKALINITY LB/DAY	HARDNESS MG/L	HARDNESS LB/DAY	SULFATES MG/L	SULFATES LB/DAY	TDI. MG/L	IRON LB/DAY	MANGANESE MG/L	MANGANESE LB/DAY	FLOW GPM
410737	D	9	7.5	1200	2	0	80	7	665	63	660	63	2.	0.1	2.9	0.28	8
410738	D	9	3.2	7800	3130	751	0	0	3200	768	2000	480	550.	132.0	99.9	23.98	20
410739	D	9	3.0	7000	1135	612	0	0	2480	1339	2100	1134	8.	4.2	92.0	49.68	45
410740	D	9	5.2	1300	445	160	0	0	442	159	1040	374	4.	1.6	11.4	4.10	30
410741	D	2	3.4	3500	970	139	0	0	1180	169	2520	362	8.	1.2	21.0	3.02	12
410742	D	6	4.2	2600	1070	128	0	0	780	93	2030	243	9.	1.0	39.0	4.68	10
410743	D	6	5.5	2500	175	14	2	0	1510	126	1800	151	1.	0.0	9.0	0.76	7
410744	C	1	6.4	1600	526	18	20	0	512	18	1020	36	8.	0.3	2.5	0.09	3
410745	D	9	3.7	7000	1860	334	0	0	2340	421	4900	882	1.	0.1	99.9	17.98	15
410746	D	9	4.2	2300	570	102	0	0	750	135	1320	237	1.	0.1	39.0	7.02	15
410747	F	9	3.1	3000	1395	167	0	0	535	64	2640	316	2.	0.2	99.9	11.99	10
410748	F	9	2.8	7000	1970	165	0	0	2350	197	4800	403	50.	4.2	99.9	8.39	7
410749	D	9	2.7	2600	805	38	0	0	336	16	1365	65	40.	1.9	19.0	0.91	4
410750	F	9	3.4	4000	1100	26	0	0	1240	29	2950	70	1.	0.0	68.0	1.63	2
410751	F	9	3.6	5000	1550	223	0	0	1056	152	3120	449	0.	0.1	99.9	14.39	12
410752	D	9	3.2	3500	1425	0	0	0	410	0	2295	0	3.	0.0	99.9	0.00	0
410753	D	9	3.4	3000	1065	127	0	0	775	93	2040	244	1.	0.1	53.0	6.36	10
410754	D	9	4.7	2200	545	130	0	0	960	230	1470	352	0.	0.1	28.0	6.72	20
410755	F	9	3.3	2400	505	0	0	0	719	0	1380	0	1.	0.0	47.5	0.00	0
410756	D	9	4.4	3000	460	149	0	0	2000	648	1960	635	0.	0.1	34.0	11.02	27
410757	C	2	3.3	1500	475	131	0	0	281	77	880	242	34.	9.5	2.0	0.55	23
410758	C	2	3.1	1600	390	23	0	0	300	18	820	49	16.	1.0	2.0	0.12	5
410759	F	2	2.9	2200	820	354	0	0	280	120	1250	540	70.	30.2	7.5	3.24	36
410760	C	2	2.8	3500	1225	220	0	0	575	103	1640	295	58.	10.4	27.2	4.90	15

RACCOON CREEK, PENNSYLVANIA

MINE NO.	TYPE	REC. STREAM	PH	COND.	ACIDITY MG/L	ACIDITY LB/DAY	ALKALINITY MG/L	ALKALINITY LB/DAY	HARDNESS MG/L	HARDNESS LB/DAY	SULFATES MG/L	SULFATES LB/DAY	TOT. IRON MG/L	TOT. IRON LB/DAY	MANGANESE MG/L	MANGANESE LB/DAY	FLOW GPM
410761	D	2	3.4	2000	575	34	0	0	610	36	1275	76	32.	1.9	22.5	1.35	5
410762	E	2	3.1	2500	895	32	0	0	455	16	1470	52	70.	2.5	8.4	0.30	3
410763	E	2	2.9	2600	875	31	0	0	460	16	1400	50	52.	1.9	13.3	0.48	3
410764	E	2	2.9	2400	750	162	0	0	312	67	1050	226	47.	10.1	5.4	1.17	18
410765	E	2	3.0	2500	940	169	0	0	350	63	1530	275	69.	12.4	9.0	1.62	15
410766	E	2	2.8	3000	1195	258	0	0	372	80	1800	388	96.	20.7	14.4	3.11	18
410767	C	2	2.6	3500	1335	48	0	0	298	10	1890	68	117.	4.2	8.1	0.29	3
410768	D	2	2.8	3000	1155	0	0	0	366	0	1880	0	94.	0.0	11.2	0.00	0
410769	D	2	3.2	2400	885	637	0	0	680	489	1620	1166	4.	3.0	13.8	9.94	60
410770	D	2	4.1	2600	860	51	0	0	552	33	1960	117	69.	4.1	39.2	2.35	5
410771	C	2	2.8	2600	895	1611	0	0	408	734	1645	2961	57.	103.3	9.1	16.38	150
410772	D	2	2.9	1800	500	0	0	0	339	0	875	0	20.	0.0	5.5	0.00	0
410773	C	2	2.8	2600	935	224	0	0	404	96	1400	336	38.	9.1	7.7	1.85	20
410774	D	2	3.2	950	135	4	0	0	178	6	370	13	3.	0.1	1.8	0.06	3
410775	D	2	6.6	1000	0	0	51	6	452	59	440	58	1.	0.1	1.6	0.21	11
410776	E	2	3.6	1700	405	97	0	0	514	123	950	228	2.	0.4	10.5	2.52	20
410777	DJ	1	3.4	3500	1755	84	0	0	644	30	2610	125	82.	3.9	57.6	2.76	4
410778	*	1	6.7	3500	115	63	0	0	440	242	1395	770	72.	39.7	2.7	1.49	46
410779	D	9	4.3	2200	885	31	0	0	472	16	1475	53	4.	0.1	8.5	0.31	3
410780	C	8	2.9	2200	785	28	0	0	372	13	1400	50	73.	2.6	3.0	0.11	3
410781	C	8	2.9	5000	2370	1706	0	0	508	365	3480	2505	96.	69.1	28.8	20.74	60
410782	C	8	3.0	7000	4580	3297	0	0	2500	1800	6600	4752	260.	187.2	60.0	43.20	60
410783	C	8	3.1	5500	3065	0	0	0	665	0	4500	0	143.	0.0	33.6	0.00	0
410784	C	9	3.7	9999	2550	919	0	0	1160	417	9125	3285	120.	43.2	62.5	22.50	30

RACCOON CREEK, PENNSYLVANIA

MINE NO.	TYPE	REC. STREAM	PH	COND.	ACIDITY MG/L	ACIDITY LB/DAY	ALKALINITY MG/L	ALKALINITY LB/DAY	HARDNESS MG/L	HARDNESS LB/DAY	SULFATES MG/L	SULFATES LB/DAY	TOT. IRON MG/L	TOT. IRON LB/DAY	MANGANESE MG/L	MANGANESE LB/DAY	FLOW GPM
410785	D	2	4.2	2200	592	0	0	0	710	0	1500	0	1.	0.0	22.5	0.00	0
410786	D	2	3.5	6000	2950	0	0	0	655	0	4650	0	48.	0.0	99.9	0.00	0
410787	D	2	3.0	5000	1530	2203	0	0	490	705	3180	4579	126.	181.4	25.2	36.29	120
410788	D	2	5.3	3000	590	1380	0	0	1480	3463	2080	4867	1.	2.3	17.6	41.18	195
410789	D	1	3.0	4000	1460	1314	0	0	825	742	3100	2790	43.	38.7	45.0	40.50	75
410790	D	8	3.8	2500	665	598	0	0	930	837	1500	1350	2.	1.9	19.8	17.82	75
410791	D	8	3.7	5000	840	756	0	0	2310	2079	2940	2646	54.	48.6	30.0	27.00	75
410792	A	0	5.4	2600	294	635	3	6	1220	2635	1650	3564	1.	1.1	16.8	36.29	180
410793	D	8	7.7	1300	58	9	28	4	640	99	700	109	1.	0.1	2.6	0.41	13
410794	D	2	7.4	2100	0	0	96	11	1295	155	1250	150	0.	0.0	0.4	0.05	10
410795	D	2	7.2	1900	42	0	4	0	1120	0	1225	0	1.	0.0	1.5	0.00	0
410798	D	7	3.3	1900	635	3962	0	0	460	2870	3325	20748	175.	1092.0	28.5	177.84	520
410799	D	8	3.2	4000	2165	1013	0	0	810	379	1000	468	33.	15.4	6.9	3.23	39
410800	H	8	6.6	7000	1765	5718	0	0	1340	4341	5250	17010	505.	1636.2	17.5	56.70	270
411069	E	7	7.2	2800	390	1076	0	0	845	2332	1820	5023	124.	342.0	11.2	30.91	230
411070	E	1	3.0	6000	6120	50232	0	0	1160	9521	7375	60534	1008.	8269.6	50.0	410.40	684
411071	C	1	3.5	1900	560	23499	0	0	290	12169	1075	45111	40.	1678.6	4.4	184.64	3497
411072	C	8	3.1	2200	900	2235	0	0	380	943	1425	3539	46.	113.0	5.5	13.66	207
411073	D	8	7.4	590	12	1	160	23	180	25	105	15	2.	0.2	0.1	0.01	12
411074	A	0	3.7	2630	354	9978	0	0	915	25792	1800	50738	12.	338.3	16.8	473.56	2349
411075	D	2	3.9	1250	190	34	0	0	535	96	660	118	1.	0.3	5.7	1.03	15
411076	D	14	4.5	3000	474	255	0	0	1050	567	1995	1077	12.	6.4	23.7	12.80	45
411077	D	14	7.6	3500	29	0	49	0	2400	0	2295	0	6.	0.0	6.3	0.00	0
411078	D	15	3.6	5000	2075	2988	0	0	1680	2419	4020	5788	29.	41.5	99.9	143.86	120

RACCOON CREEK, PENNSYLVANIA

MINE NO.	TYPE	REC. STREAM	PH	COND.	ACIDITY MG/L	ACIDITY LB/DAY	ALKALINITY MG/L	ALKALINITY LB/DAY	HARDNESS MG/L	HARDNESS LB/DAY	SULFATES MG/L	SULFATES LB/DAY	TOT. IRON MG/L	TOT. IRON LB/DAY	MANGANESE MG/L	MANGANESE LB/DAY	FLOW GPM
411079	D	14	4.1	5000	1450	2610	0	0	1930	3474	3480	6264	7.	13.0	92.4	166.32	150
411080	D	14	7.2	4000	210	35	0	0	1930	324	2650	445	2.	0.3	11.9	2.00	14
411081	D	14	5.2	3000	605	14	0	0	1430	34	2170	52	8.	0.2	47.6	1.14	2
411082	D	14	0.0	3000	950	285	0	0	1460	438	2380	714	11.	3.2	24.1	7.23	25
411083	D	14	0.0	3000	780	421	0	0	1420	766	2205	1190	2.	1.1	18.6	10.04	45
411084	A	0	5.2	1600	380	46685	1	122	388	47668	940	115484	38.	4619.4	8.0	982.85	10238
411085	A	0	3.9	1700	340	8098	0	0	546	13005	1020	24296	5.	114.3	12.4	295.37	1985
411086	A	0	4.8	1800	315	26860	0	0	512	43659	1000	85272	6.	511.6	14.0	1193.81	7106
411087	A	0	4.7	1400	265	801	2	6	654	1977	1060	3205	1.	3.6	10.0	30.24	282
411088	A	0	6.6	3000	15	881	67	3936	2320	136,305	2345	137,773	1.	58.8	11.2	658.02	4896
411089	A	0	4.0	1700	415	243327	0	0	512	300201	1180	691871	22.	12899.3	10.0	5863.32	48861
411090	A	0	4.7	2000	375	3991	3	31	920	9792	1600	17030	4.	37.3	24.5	260.78	887
411091	D	8	4.9	3500	570	47	0	0	1421	119	3420	287	2.	0.2	54.0	4.54	7
414118	D	8	3.3	5000	2325	1255	0	0	1290	696	3840	2073	813.	438.8	19.2	10.37	45
414373	C	1	3.0	1275	285	10	0	0	325	11	675	24	10.	0.4	3.6	0.13	3
414601	D	12	4.3	2200	1950	234	0	0	1460	175	1650	198	2.	0.2	27.0	3.24	10
414602	D	12	3.4	4000	1485	89	0	0	1130	67	4250	255	468.	28.1	58.0	3.48	5
414603	D	13	4.5	3000	650	31	0	0	1850	88	2280	109	13.	0.6	33.6	1.61	4
414604	D	13	3.2	5200	3950	379	0	0	1060	101	6675	640	870.	83.5	82.5	7.92	8
414605	D	13	3.3	4500	2735	98	0	0	1120	40	4680	168	247.	8.9	99.9	3.60	3
414606	GJ	13	3.9	4500	2415	869	0	0	1320	475	4620	1663	324.	116.6	68.4	24.62	30
414607	D	13	3.7	4000	1635	39	0	0	1720	41	3800	91	185.	4.4	95.0	2.28	2
414608	D	13	3.1	4000	2225	26	0	0	620	7	3500	42	285.	3.4	30.0	0.36	1
414609	D	13	6.5	2800	85	1	25	0	1725	20	2065	24	9.	0.1	35.0	0.42	1

RACCOON CREEK, PENNSYLVANIA

MINE NO.	TYPE	REC. STREAM	PH	COND.	ACIDITY MG/L	ACIDITY LB/DAY	ALKALINITY MG/L	ALKALINITY LB/DAY	HARDNESS MG/L	HARDNESS LB/DAY	SULFATES MG/L	SULFATES LB/DAY	TOT. IRON MG/L	TOT. IRON LB/DAY	MANGANESE MG/L	MANGANESE LB/DAY	FLOW GPM
414610	C	13	2.8	5000	3245	38	0	0	810	9	5820	69	500.	6.0	36.0	0.43	1
414611	E	13	3.2	3700	1500	144	0	0	91	8	2925	280	162.	15.6	35.1	3.37	8
414612	D	13	3.4	2000	690	0	0	0	600	0	1550	0	9.	0.0	30.0	0.00	0
414613	E	13	3.1	2800	830	79	0	0	935	89	1960	188	31.	3.0	16.1	1.55	8
414614	C	12	7.0	2800	0	0	170	2	1290	15	1820	21	2.	0.0	2.1	0.03	1
414615	E	13	3.0	5200	2880	2937	0	0	775	790	5250	5355	815.	831.3	34.5	35.19	85
414616	F	13	3.3	4500	2370	28	0	0	1150	13	4440	53	680.	8.2	85.2	1.02	1
414617	D	13	7.5	3000	275	16	0	0	1950	117	2200	132	16.	1.0	33.6	2.02	5
414618	D	13	3.1	6000	2525	60	0	0	1520	36	5100	122	281.	6.7	31.5	0.76	2
414619	E	12	4.5	1900	450	43	0	0	730	70	1275	122	8.	0.7	13.0	1.25	8
414620	D	12	3.6	3000	1800	21	0	0	710	8	2400	28	8.	0.1	39.2	0.47	1
414621	D	13	3.1	5000	3090	1779	0	0	1140	656	5460	3144	670.	385.9	34.8	20.04	48
414622	D	13	3.4	4500	830	69	0	0	2050	172	3180	267	66.	5.5	21.6	1.81	7
414623	D	13	7.0	4500	880	232	116	30	2450	646	3960	1045	11.	2.9	52.8	13.94	22
414624	E	13	3.1	3000	790	142	0	0	1260	226	2240	403	11.	2.0	35.2	6.34	15
414625	E	12	3.3	1900	625	60	0	0	470	45	1175	112	27.	2.5	5.5	0.53	8
414626	F	12	3.0	4100	2400	28	0	0	860	10	3550	42	490.	5.9	15.0	0.18	1
414627	F	13	3.1	3900	1355	81	0	0	990	59	2200	132	38.	2.3	18.0	1.08	5
414628	E	13	3.2	4200	2714	2117	0	0	1070	834	2200	1716	130.	101.4	35.0	27.30	65
414629	C	12	3.1	8460	4625	444	0	0	940	90	0	0	0.	0.0	0.0	0.00	8
414630	E	12	6.6	6000	1580	18	82	0	1550	18	5100	61	92.	1.1	91.5	1.10	1
414631	E	12	7.0	4000	380	27	200	14	1730	124	2400	172	8.	0.6	10.0	0.72	6
414632	A	0	3.4	2850	865	10649	0	0	765	9418	1680	20684	31.	379.2	19.6	241.32	1026